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Space Administration

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Pasadena, California

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# AIRS Project Status

T. Pagano

April 26, 2011



Dedicated to  
Mous Chahine

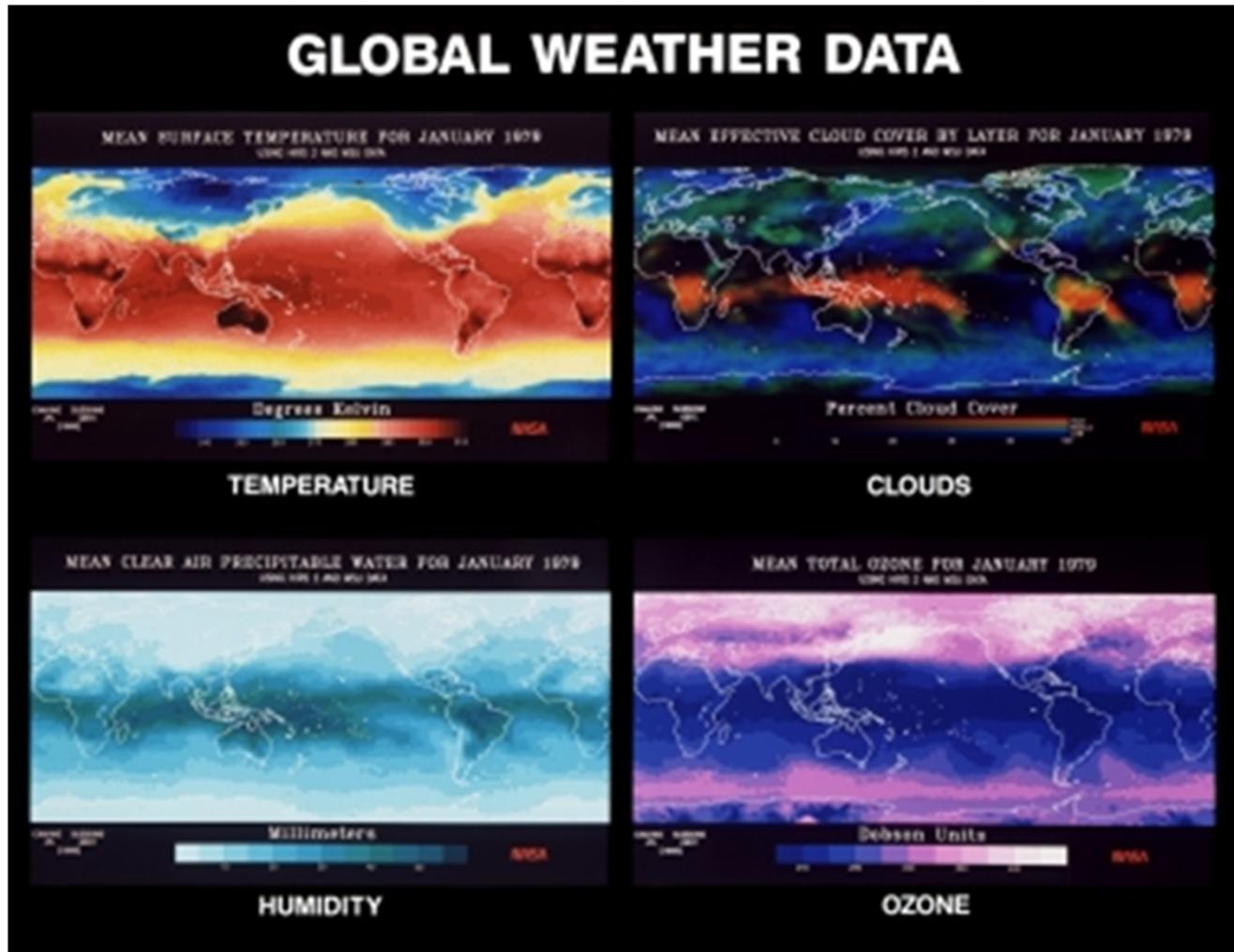
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# First Sounder Global Images from Dr. Chahine 1979



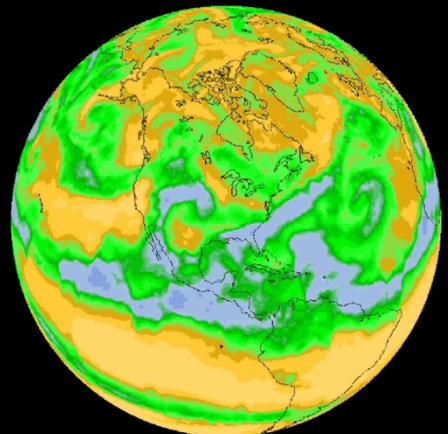


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## Today's Greenhouse Gases from AIRS

$H_2O$

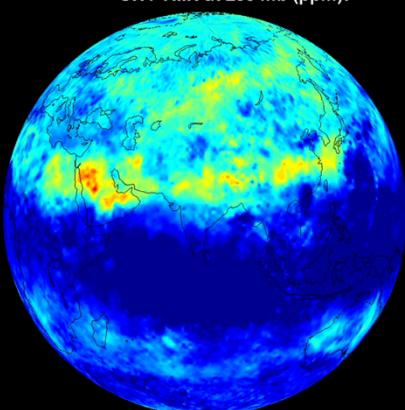
500 mb Water Vapor (g/kg dry air)



2005.08.01

$CH_4$

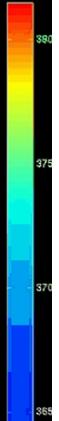
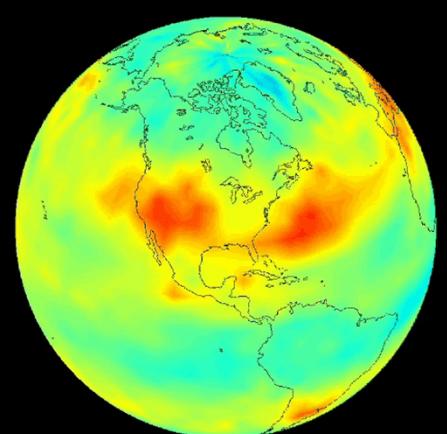
$CH_4$  VMR at 200 mb (ppm):



2004\_08\_27

$CO_2$

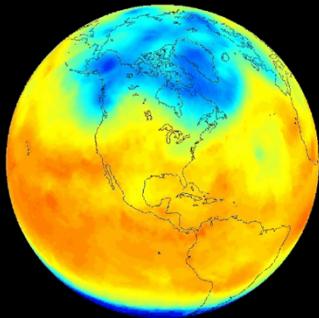
Mid-Tropospheric  $CO_2$  (ppm)



Pagano, JPL, 2009

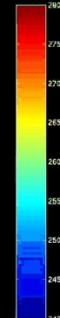
## Other AIRS Atmospheric Climate Products

500 mb Temperature (K)

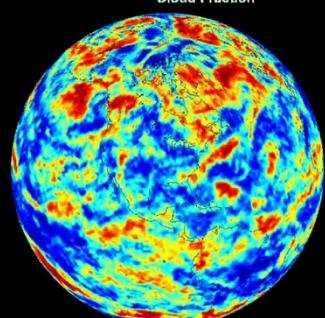


2005.08.01

Temperature



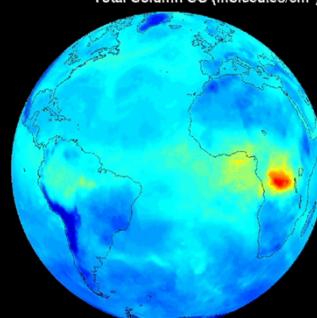
Cloud Fraction



2005.08.01

Clouds

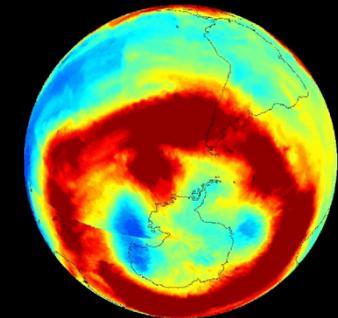
Total Column CO (molecules/cm<sup>2</sup>)



5.08.01

CO

Total Column Ozone (DU)



01

O<sub>3</sub>



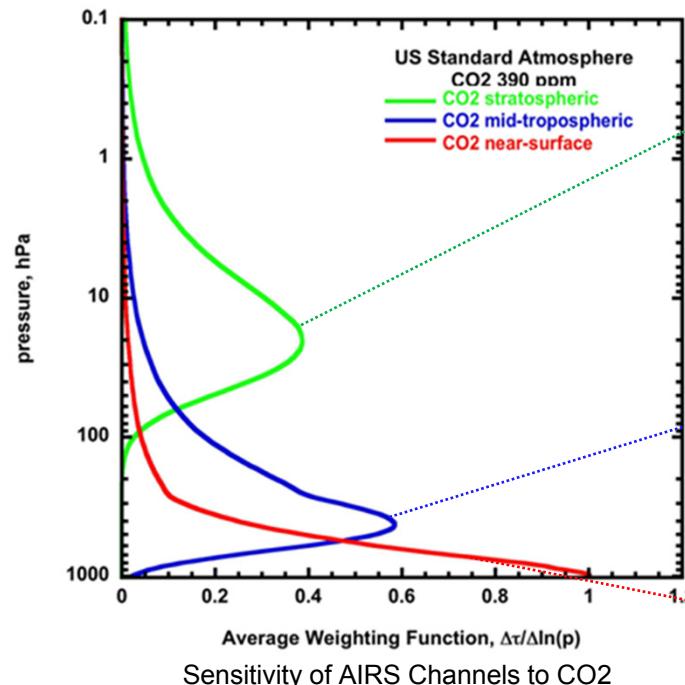


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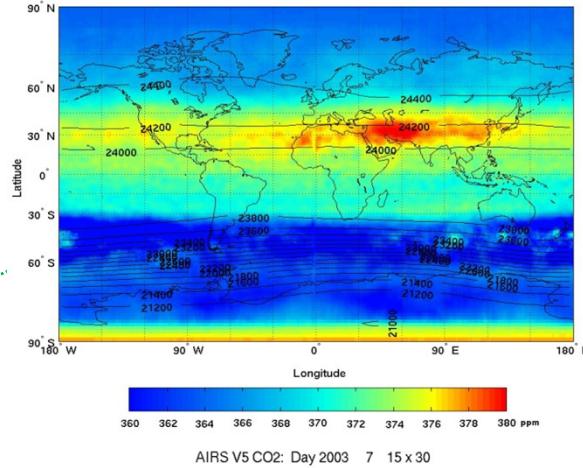
## 3 Layers of CO<sub>2</sub> Derived from AIRS by Dr. Chahine, and Colleagues, 2011 Images for July 2003

Stratosphere

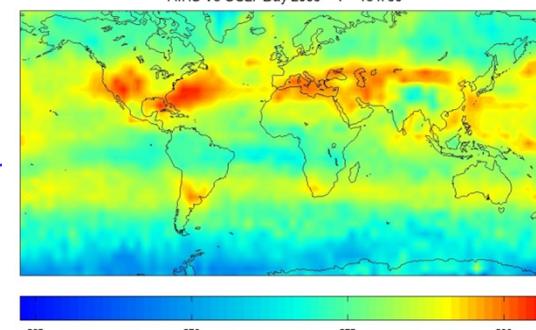


Mid-Troposphere

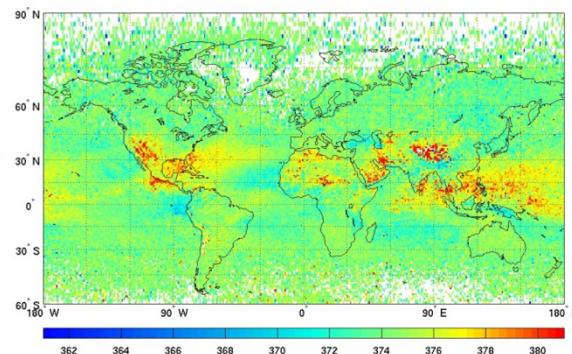
Lower Trop



Preliminary



Validated  
Sept 02 - Present



Preliminary

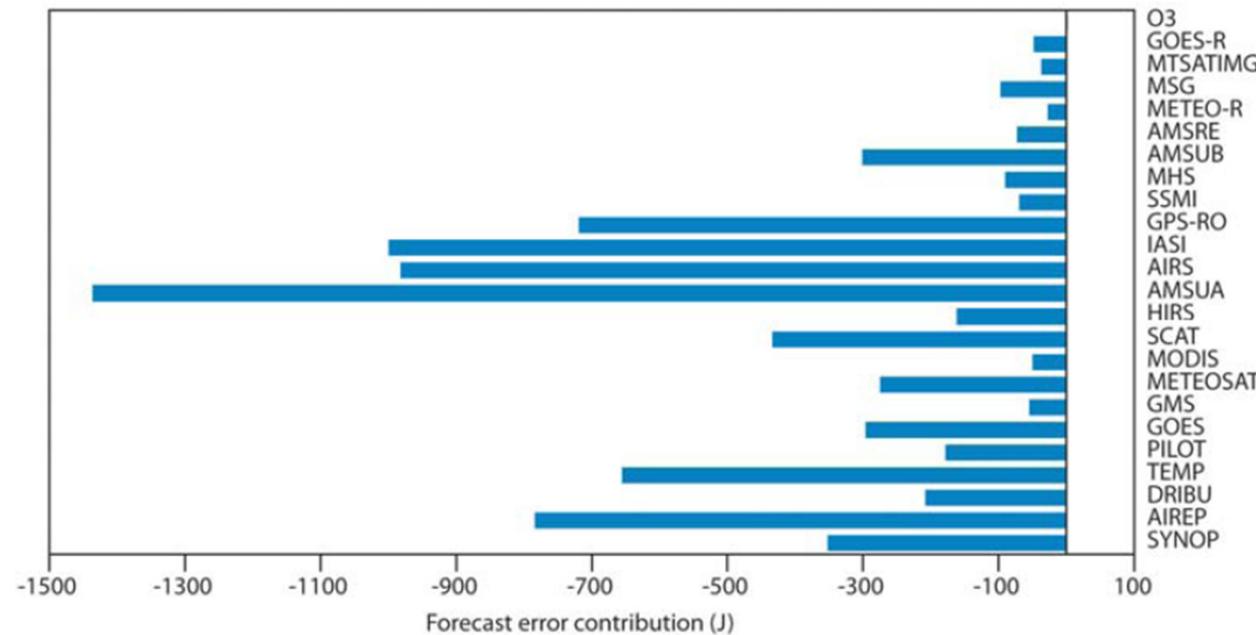


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# ECMWF Finds High Infrared Sounder Impact

- Microwave satellite measurements (AMSU-A) are responsible for 18% of the forecast error reduction
- Infrared measurements (AIRS and IASI) for 12% each
  - 10% of error reduction is due to radio occultation

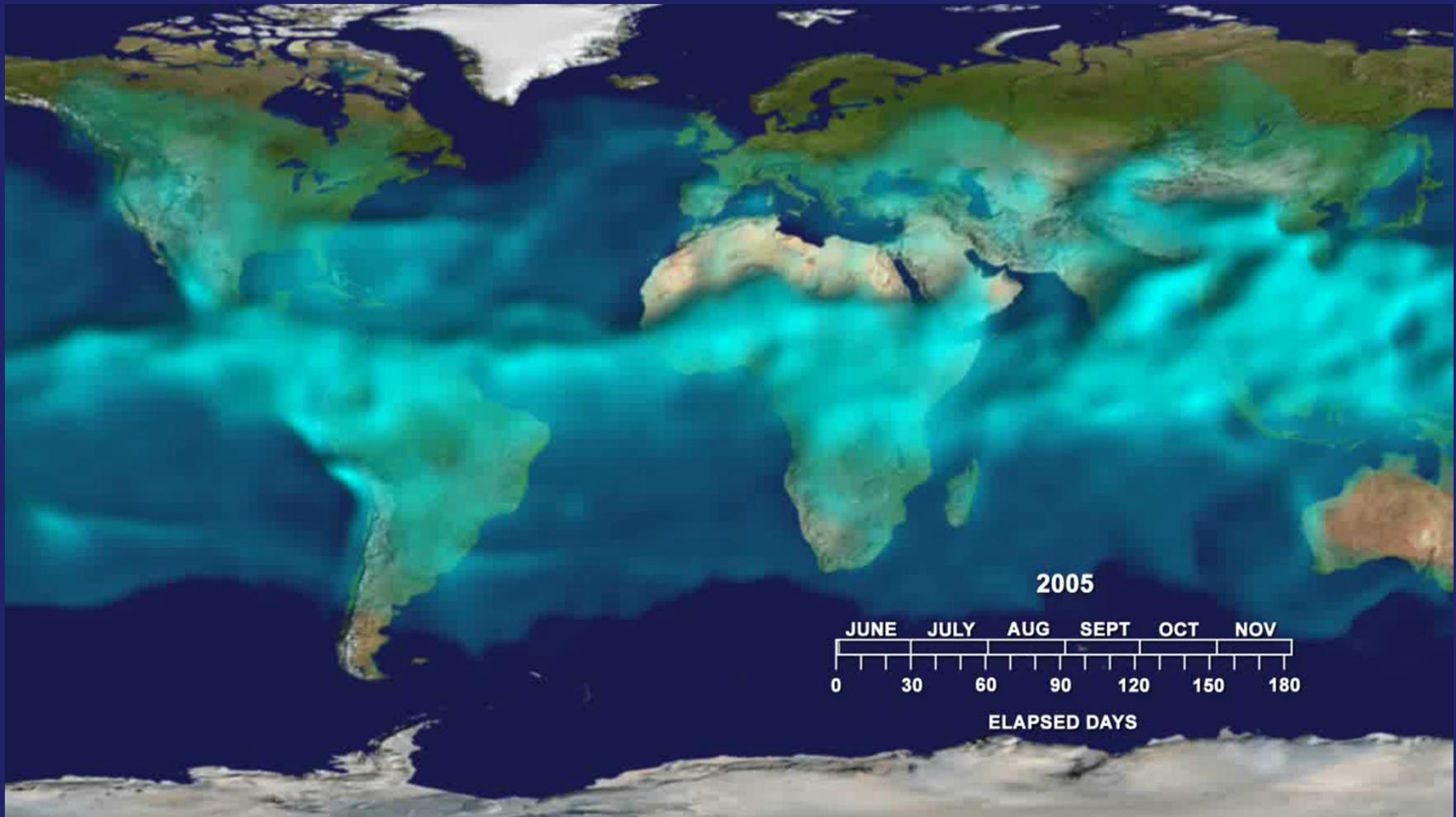


From Cardinali (ECMWF Tech. Memo. 599, 2009), See also, Cardinali, C, Monitoring the observation impact on the short-range forecast, Q. J. R. Meteorol. Soc. 135: 239–250 (2009)



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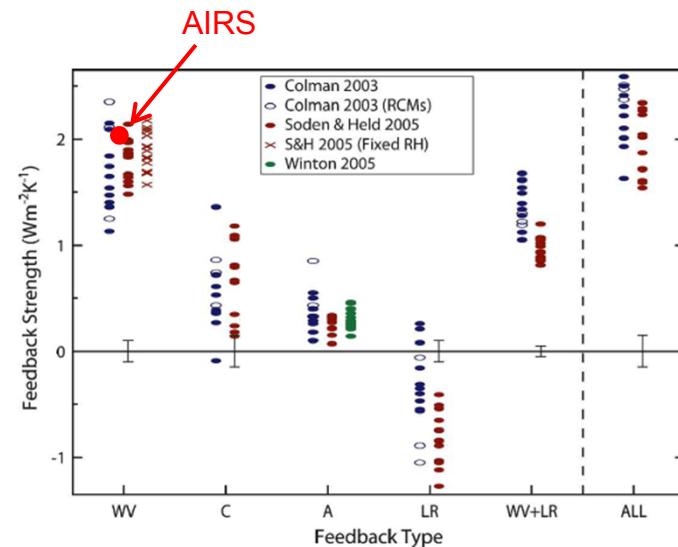
# AIRS Gives First Look at Water Waves in the Atmosphere



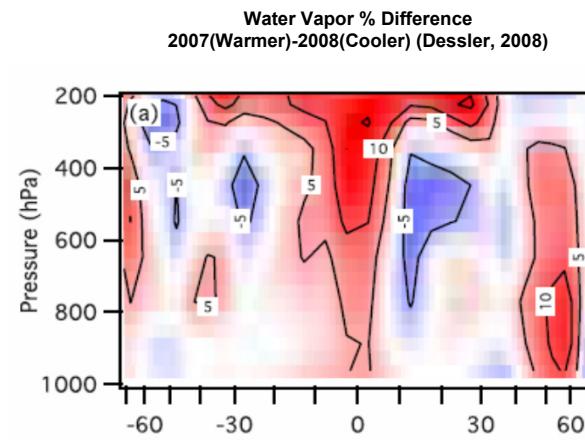


# AIRS Data Used to understand Climate Feedbacks

- AIRS Water Vapor Profiles provide good sensitivity to interannual differences
- Difference between warm year and cooler years give a measure of response of water vapor to warming
- Results show a positive upper tropospheric water vapor feedback
  - Dessler, A. E., Z. Zhang, and P. Yang (2008), Water-vapor climate feedback inferred from climate fluctuations, 2003-2008, *Geophys. Res. Lett.*, 35, L20704, doi:10.1029/2008GL035333.
  - Gettelman, A., Fu, Q., “Observed and simulated upper-tropospheric water vapor feedback”, *Journal of Climate*, 2008, 21, 13, 3282-3289



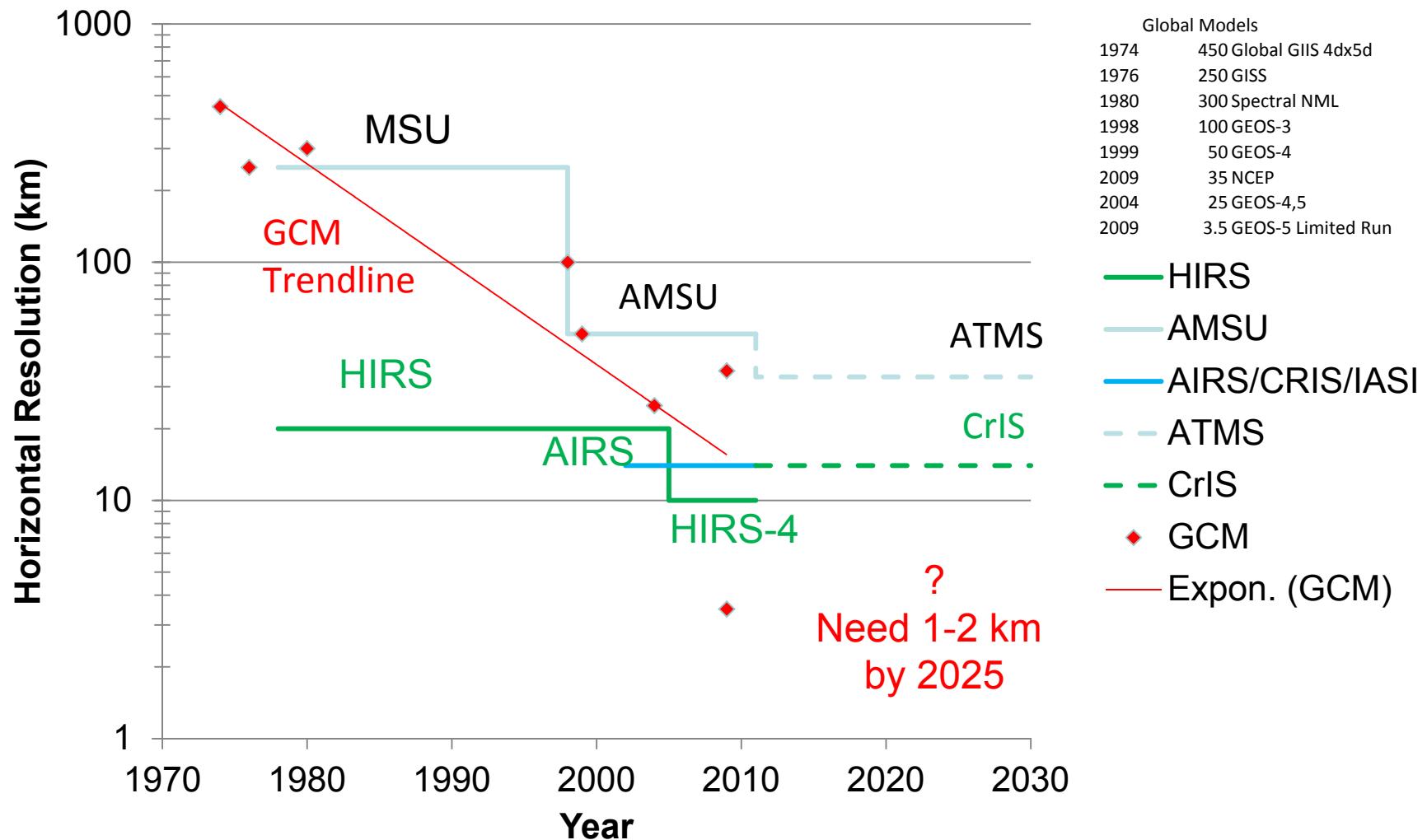
Bony, S., et al., “How Well Do We Understand and Evaluate Climate Change Feedback Processes?”, *Journal of Climate*, Vol 19, p 3445-3482.





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# Improved Spatial Resolution from LEO Needed to Initialize & Validate GCM's

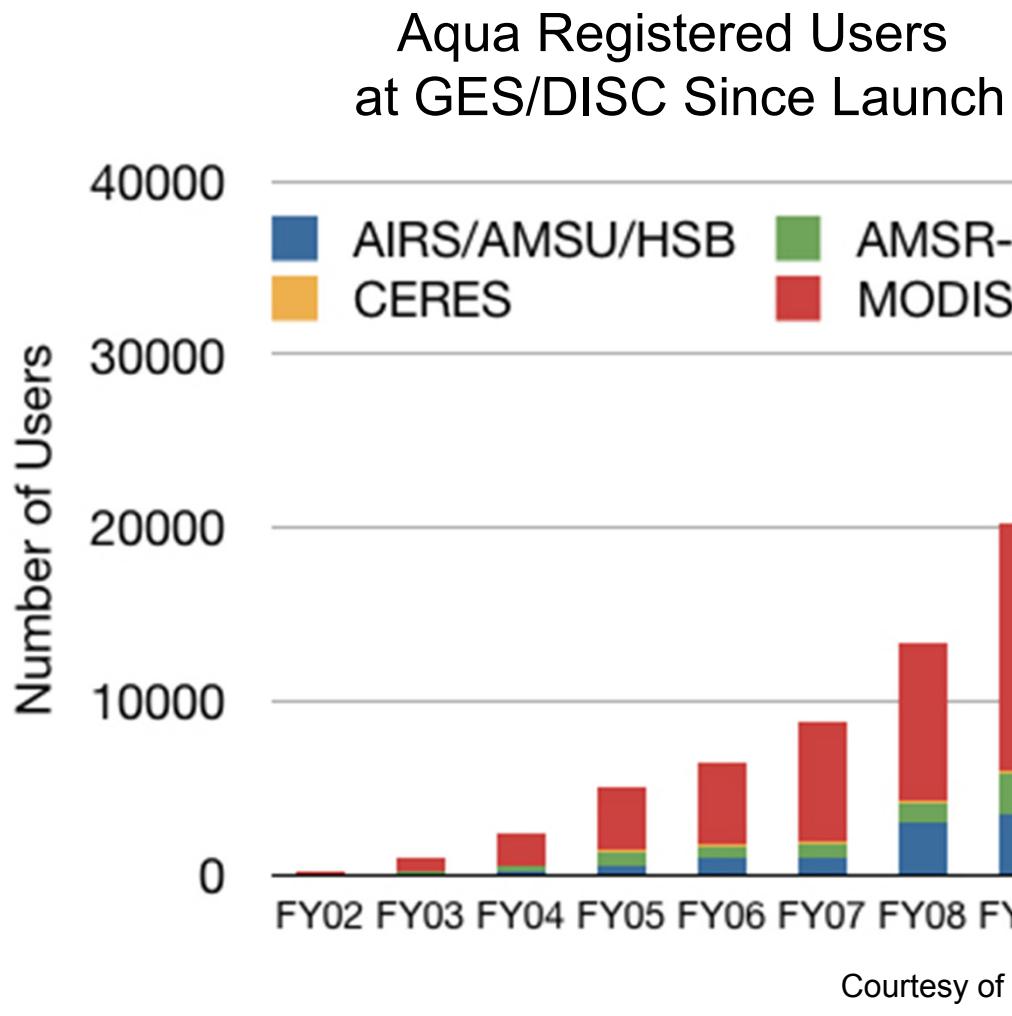


Observations of Temperature, Water Vapor, Clouds, etc. are used to initialize and validate forecast models  
AIRS Science Team Meeting, April 26, ,2011, T. Pagano (JPL)

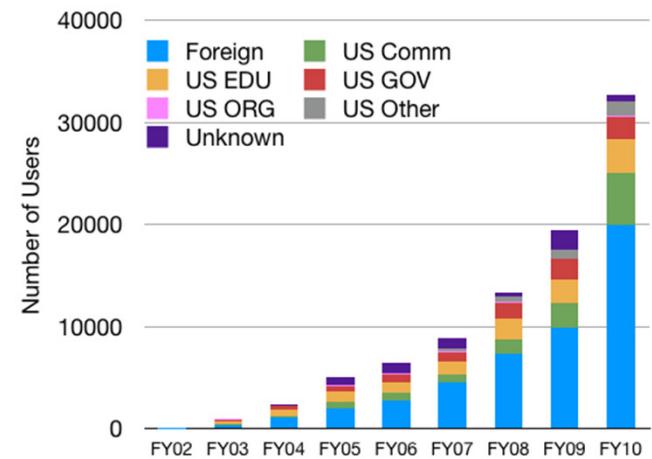


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# Higher Spatial Resolution Relevant to More Users: See Aqua



### Truly Global User Base



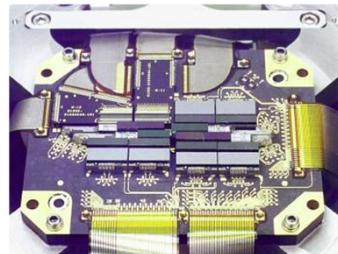
**LEO Imagers and  
Sounders are Essential to  
Earth Science  
Investigations and Must be  
Priority for Future  
Upgrades.**



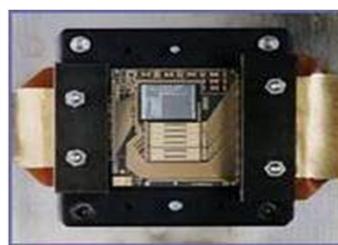
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# AIRS/MODIS Technology Has Evolved Since the 1990's

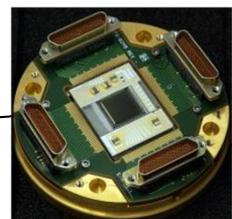
AIRS  
BAE Systems  
PV/PC HgCdTe  
17 modules  
2 x ~180  
100 x 50  $\mu\text{m}$



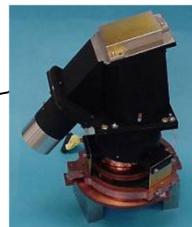
MODIS  
Raytheon Vision  
Systems  
PV/PC HgCdTe  
4 FPA  
10 x ~10  
400 x 400  $\mu\text{m}$



BAE Systems  
HgCdTe  
15  $\mu\text{m}$  Cutoff  
512 x 512



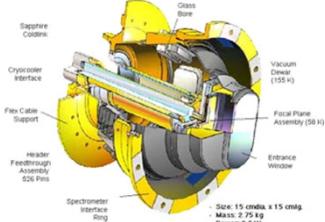
SIRAS IIP1  
Refractive 16°  
Grating Spectr



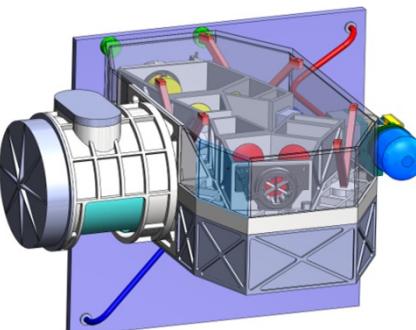
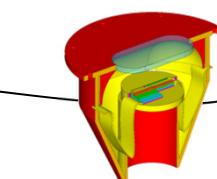
AIRS  
Reflective 1.1°  
Grating Spectr



AIRS  
Large Dewar



High Efficiency  
Mini Dewars



*Atmospheric  
Remote-sensing  
Imaging  
Emission  
Sounder  
(ARIES)*

AIRS  
Large Dual Pulse  
Tube Coolers



NGST  
Small Single  
Pulse Tube  
Cooler

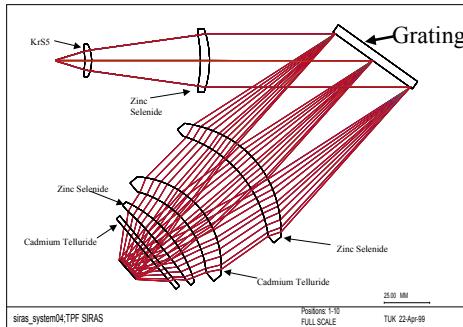




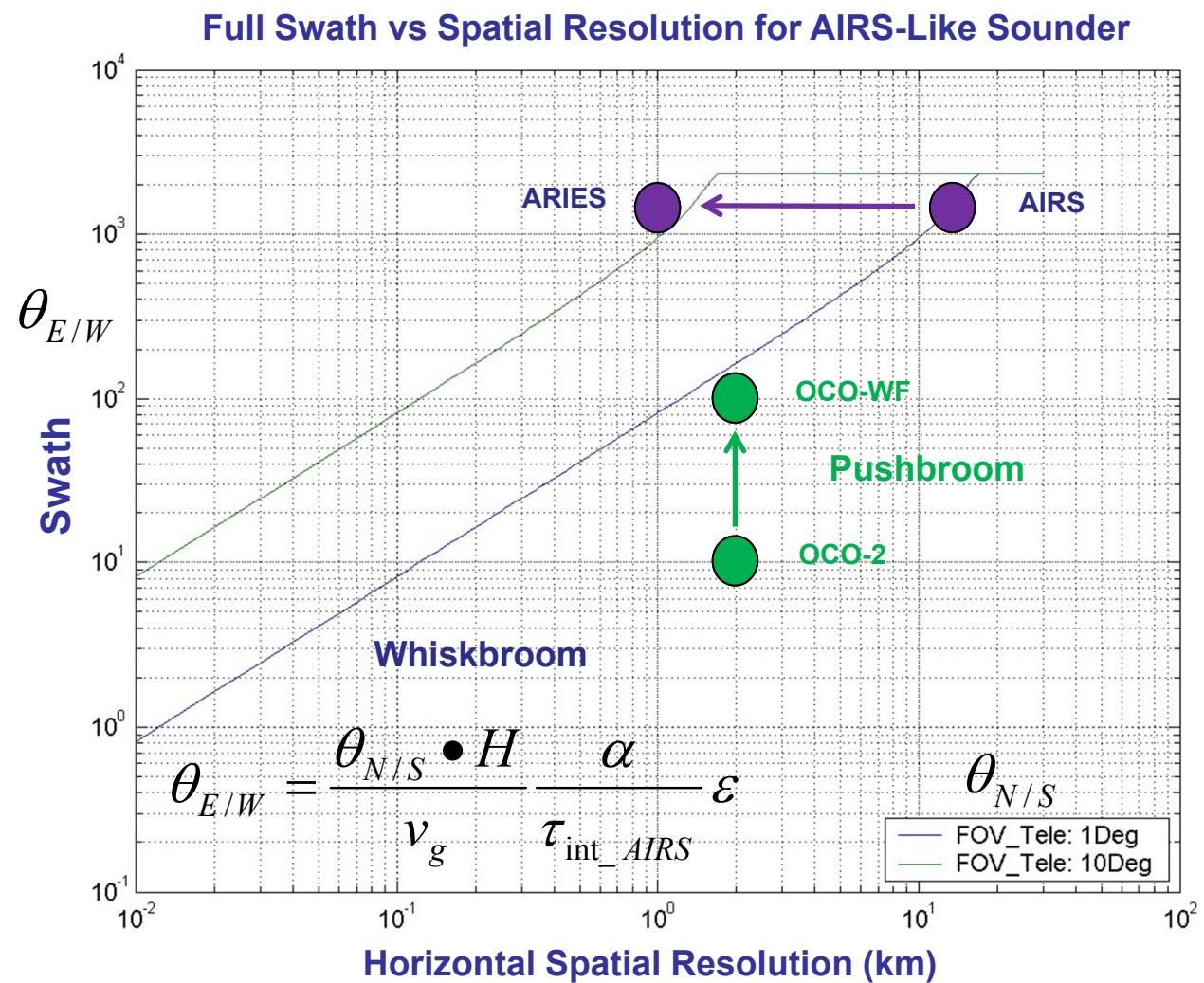
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# Wide Field Optics Improve Spatial Resolution and/or Coverage

Wide Field Grating Spectrometer  
Demonstrated on IIP 2001



- **Whiskbroom:** Wide field slows scan, enabling higher spatial resolution
- **Pushbroom:** Wide field directly extends E/W Swath





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# High Spatial Resolution (1km) AIRS / Hyperspectral MODIS Now Possible

## AIRS

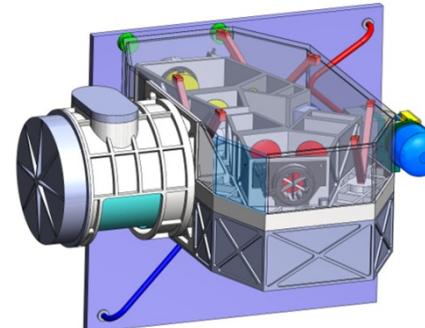


AIRS on Aqua  
14 km GSD,  $\pm 49.5^\circ$   
2378 Channels  
0.4-15.4  $\mu\text{m}$   
177 kg, 256 W  
0.9  $\text{m}^3$ , 1.3 Mbps

For example:

## ARIES (IR, JPL)

Atmospheric Remote-sensing Imaging Emission Sounder



1 km GSD.  $\pm 55^\circ$   
4096 Channels  
3.3-15.4  $\mu\text{m}$   
100 kg, 150 W  
0.5  $\text{m}^3$ , 60 Mbps  
**Unplanned**

## MODIS

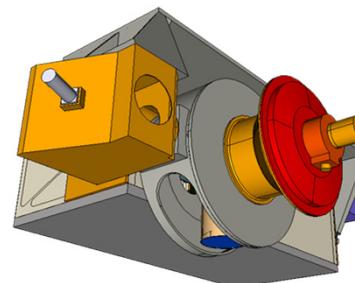


MODIS on Aqua  
1 km GSD,  $\pm 55^\circ$   
0.4-14.4  $\mu\text{m}$   
220 kg, 160 W  
1.5  $\text{m}^3$ , 11 Mbps

For example:

## ORCA (Solar Reflective, GSFC)

Ocean Radiometer for Carbon Assessment



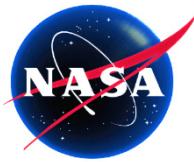
1 km GSD.  $\pm 58^\circ$   
108 Channels  
0.24-2.14  $\mu\text{m}$   
140 kg, 130 W  
0.5  $\text{m}^3$ , 13 Mbps

**NASA Planned  
(For PACE)**

- **ARIES and ORCA Meet all Requirements of AIRS and MODIS + More!!!**

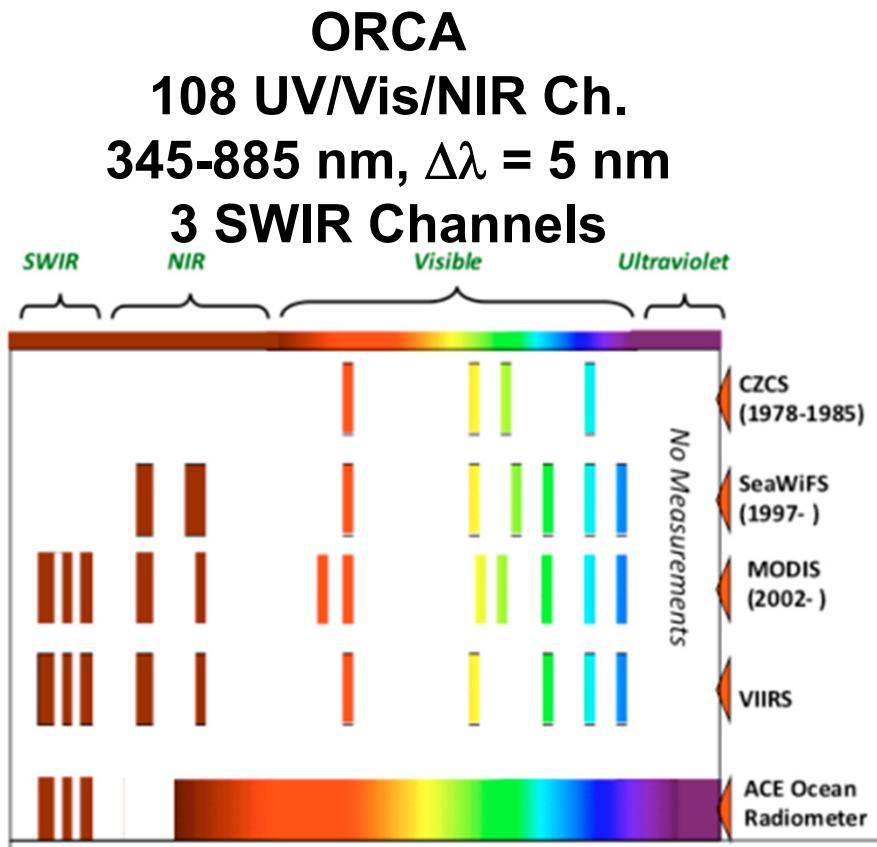
T.S. Pagano, C.R. McClain, "Evolution of Satellite Imagers and Sounders for Low Earth Orbit and Technology Directions at NASA", Proc. SPIE, 7807-20, San Diego, California, August 2010

AIRS Science Team Meeting, April 26, 2011, T. Pagano (JPL)

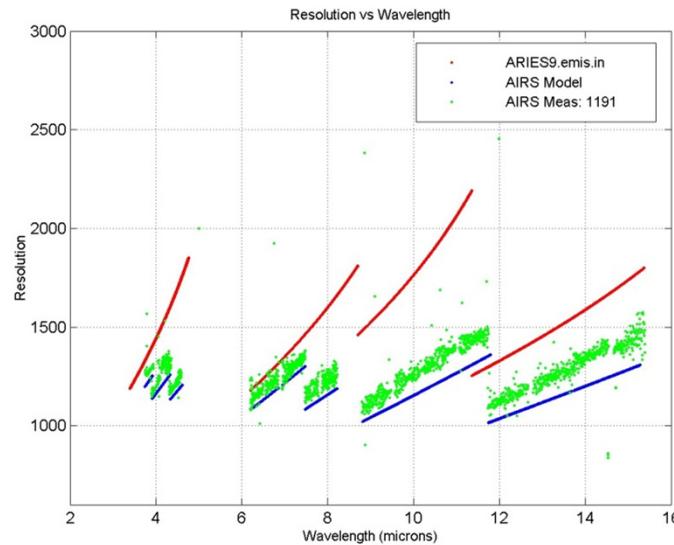


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# Next Gen Imaging Sounders Give Hyperspectral UV through LWIR



**ARIES**  
**4096 Channels**  
**~2x Better than AIRS**



Band	Spectral Range	Spectral Resolution	No. Channels
MW1	$2100 - 2950 \text{ cm}^{-1}$	$1.6 \text{ cm}^{-1}$	1024
MW2	$1150 - 1613 \text{ cm}^{-1}$	$1.0 \text{ cm}^{-1}$	1024
LW1	$880 - 1150 \text{ cm}^{-1}$	$0.6 \text{ cm}^{-1}$	1024
LW2	$650 - 880 \text{ cm}^{-1}$	$0.5 \text{ cm}^{-1}$	1024

T.S. Pagano, C.R. McClain, "Evolution of Satellite Imagers and Sounders for Low Earth Orbit and Technology Directions at NASA", Proc. SPIE, 7807-20, San Diego, California, August 2010

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# AIRS Project Status Summary

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- **Instrument Operations:** AIRS Working Well. AMSU Ch 5 Concern
- **Instrument Calibration:** Excellent. New lead on overlap channel biases
- **Level 1B Validation:** Can't wait for CrIS. We see 50 mK errors.
- **Software Integration and Production:** V6 Near Completion
- **Data Processing Operations:** Testing Data Sets Processed
- **L2 Algorithm Assessment and Integration:** V6 Testing Begun
- **L2 Product Validation:** Many improvements in V6 performance
- **Project Science:** New Products: L1C, CAPE, LI, Clouds, CO2
- **Climate Data Records Development:** CMIP5/IPCC
- **User Services:** Over 788 Registered on AIRS site alone
- **EPO:** Captures best of the AIRS Project. <http://airs.jpl.nasa.gov>
- **Project Management:** On Budget – Behind Schedule,  
2010 NASA Science Community Workshop Draft Report Released,  
Sr. Review Proposal Submitted, Keep Making Progress!!!

*Presentations by all Element Leads Today*



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# Mous Chahine's legendary phrases we will never forget...

- **AIRS Inception:** “1K/km”
- **AIRS Development:**  
“Always Make Progress”
- **AIRS Validation:** “We do it  
Day, Night, Land, Ocean, and  
in the Presence of Clouds”
- **CO<sub>2</sub> Retrieval Development:**  
“Every millikelvin counts”
- **To the public:** “This is what  
CO<sub>2</sub> would look like if you  
could see it”
- **For the future:** “AIRS at  
1km, ARIES”
- Thank You Mous!



*A Brilliant Scientist  
A Great Visionary  
A Caring Mentor  
A Good Friend*